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Effect of organic manures and nutrient management practices on growth, yield and quality parameter of safflower under *rainfed* condition

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Abstract
The field experiment was conducted at experimental farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *rabi* season 2017-18, to find out the effect of different organic manures and nutrient management practices on growth, yield and quality parameter of safflower under *rainfed* condition. Experimental finding revealed that, among the different sources organic manures, the treatment with application of FYM @ 5 t ha^{-1} registered significantly higher in growth attributes *viz*. plant height (75.78 cm), number of branches plant^{-1} (15.58), leaf area plant^{-1} (37.60 dm^2), dry matter accumulation plant^{-1} (67.24 g), seed yield (1745 kg ha^{-1}), straw yield (4661 kg ha^{-1}), biological yield (6406 kg ha^{-1}), harvest index (27.21%) and quality character i.e. oil content (28.16%) and protein content (12.82%) as compared to treatment of no manure. However, it was found statistically similar with greengram residue incorporation treatment. Significantly lowest growth attributes, yield and quality parameter were displayed with the treatment of no manure. Out of five nutrient management treatments, application of fertilizer with SSNM (STCR equation) + ($ZnSO_4$ @ 25 kg ha^{-1} + S @ 10 kg ha^{-1}) produced significantly highest growth attributes such as plant height (80.42 cm), number of branches plant^{-1} (17.43), and dry matter accumulation plant^{-1} (70.37 g), seed yield (1818 kg ha^{-1}), straw yield (4948 kg ha^{-1}), biological yield (6767 kg ha^{-1}) and harvest index (26.86%), which was found statistically identical with treatment of SSNM (STCR equation) superior over other nutrient management treatments. In case of leaf area plant^{-1} (40.24 dm^2), oil content (29.49%) and protein content (13.11%) were recorded significantly highest with fertilizer applied in SSNM (STCR equation) + ($ZnSO_4$ @ 25 kg ha^{-1} + S @ 10 kg ha^{-1}) than rest remaining treatments. The lowest value in respect of growth attributes, yield and quality parameter of safflower were recorded under treatment of no fertilizer.

Keywords: Safflower, site specific nutrient management, FYM, greengram residue incorporation

Introduction
Safflower is an important oilseeds crop of Vidarbha region of Maharashtra mainly grown after short duration crop. The maximum yield potential of safflower can be realized by adopting suitable agronomic practice like use of fertilizer dose, timely sowing and maintaining optimum plant density (Sakir and Baslama, 2005) [16]. It is more drought resistance than other oilseeds and can produce good yield in dry region, while its salt tolerance is a valuable asset as the area affected by some degree of salinity steadily increases.

In Maharashtra, safflower is grown as sole crop as well as in mixed cropping system during *rabi* season and is predominantly raised in black soils of Marathwada region and up to some extent in Vidharbha region of Akola, Buldhana and also grown in Amravati and Yavatmal districts. In Maharashtra, it is being cultivated over an area of 0.39 lakh ha with a production of 0.21 lakh tonnes and the productivity is 548 kg/ha (Anonymous 2018) [6]. In Vidharbha region, safflower occupies 210 ha area with 130 tons production and having 1025.6 kg/ha productivity (Anonymous 2017) [5].

Higher dose of chemical fertilizer and agricultural chemicals but inadeqqate use of organics leads to negative results on fertility and productivity of soil. By and large, traditionally, safflower is grown in Vertisols soils showed either deficiency or inadequacy in cluster of major and micronutrients. Regular and prolonged exploitation of soil resources for crop cultivation without addition of fertilizers and inadequate supply of fertilizers create nutrient

imbalance in soil. Due to continuous growing of legumes, regular application of P and N fertilizers, the native micro-nutrient content in soil often becomes inadequate for crops. However, requirement of sulphur and zinc to safflower crop is relatively high. It is important to increase the production of safflower by adding adequate quantity of fertilizers including micronutrients (Singh *et al.*, 2008) [18].

Materials and Methods

A field experiment was conducted at experimental farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS), during *rabi* season of 2017-18. To investigate response of organic manures and nutrient management on growth, yield and quality parameter of safflower under *rainfed* condition. Objective is to assess the safflower growth, yield and quality under different nutrient management practices. The experimental soil was medium deep black, alkaline reaction pH (8.0), EC (0.30 dSm^{-1}), low in available nitrogen (194.0 kg ha^{-1}), medium in available phosphorus (26.10 kg ha^{-1}) and slightly high in available potassium (327 kg ha^{-1}). The status of organic carbon content (0.59) which was medium in category. Fertilizers were applied to the crop based on uptake pattern, target yield and fertility status. Initial value of available nitrogen (194 kg ha^{-1}), phosphorus (26.10 kg ha^{-1}) and potassium (327 kg ha^{-1}) were considered to calculate the fertilizer requirement for targeted yields of safflower. Fertilizer adjustment equation employed for calculation of nutrient requirement for safflower crop and major nutrients applied on the basis of soil test values under different treatments i.e. F.N = 9.11 x T – 0.45 x S.N; F. P_2O_5: 6.27 x T – 2.19 x S. P; F. K_2O: 9.27 x T – 0.38 x S. K and target yield was taken 15 q/ha. The experiment was laid out in FRBD with fifteen treatments combination *viz.*, Factor A consisting three treatments M_0 - No manure, M_1- 5 t FYM ha^{-1} and M_2 - greengram residue incorporation likewise Factor B consist of five nutrient management treatments i.e. F_0- control (no fertilizer), F_1- Recommended NPK, F_2- SSNM (STCR equation), F_3- SSNM (STCR equation) + ($ZnSO_4$ @ 25 kg ha^{-1} + S @ 10 kg ha^{-1} and F_4 - SSNM (NPK) (deficient + 25% rec.; medium: rec.; high: - 25% rec.). This treatments combination replicated four times. The safflower crop was sown by using 12 kg ha^{-1} seed of variety AKS-207 on 6th October 2017 by keeping 45 cm x 20 cm spacing and harvesting was done 23th February 2018. Full dose of nitrogen, phosphorus, potassium, sulphur and zinc were applied to all the plots at time of sowing as per treatment details. Statistical analysis was worked out as per the method described by (Gomez and Gomez, 1984) [9]. Grain and straw yields were recorded from each plot at harvest. About 66 mm rainfall received during the crop growing season in 06 rainy days. Oil content in seed was determined by Nuclear Magnetic Resonance (NMR) method as suggested by Tiwari *et al.* (1974) [22]. The protein content of the seed was worked out by multiplying nitrogen content in the seed (per cent) with the factor 6.25 as reported by Angelo and Mann (1973) [4].

Results and Discussion

Effect of manure application

Data from Table 1 revealed that, growth attributes were significantly influenced by manure treatments. the treatment with application of (M_1) 5 t FYM ha^{-1} recorded maximum growth character like plant height (75.78 cm), number of branches $plant^{-1}$ (15.58) and dry matter accumulation $plant^{-1}$ (67.24 g) but it was found at par with treatment of (M_2) greengram residue incorporation and significantly superior over the treatment which had (M_0) no added manure. Significantly lowest growth attributes *viz*., plant height (68.75 cm), number of branches $plant^{-1}$ (13.39), leaf area $plant^{-1}$ (33.04 dm^2) and dry matter accumulation $plant^{-1}$ (60.78 g) were registered under treatment of (M_0) no manure. The highest plant height might be due to the positive effects of application of 5 tons FYM ha^{-1} which had accelerated various metabolic processes and resulted in increasing vegetative growth. The increase in number of branches per plant due to favourable effects of FYM in improving the soil fertility through positive effects on physical and chemical and biological soil properties. Similar result was recorded by Mohod *et al*. (2010) [14]. Continuous supply of nutrient might have played a potent role on enhanced cell division and elongation of leaves resulting in higher biomass (Singh *et al*., 2015) [19]. Better crop growth in this treatment might have lead to the production of higher number of leaves and in turn enhanced leaf area (Suri and Sarita 1996) [21].

Data given in Table 2 concluded that, significantly highest seed yield (1818 kg ha^{-1}) straw yield (4948 kg ha^{-1}) and biological yield (6767 kg ha^{-1}) were achieved with the treatment of 5 t FYM ha^{-1} (M_1) and treatment of greengram residue incorporation (M_2), both being statistically similar with each other and found significantly superior over the treatment no manure (M_0). Numerically highest harvest index (27.21%) was recorded with application of FYM @ 5 t ha^{-1} followed by treatments greengram residue incorporation and no manure. Similarly, the treatment with no manure (M_0) recorded lowest seed yield (1311 kg ha^{-1}), straw yield (3879 kg ha^{-1}), biological yield (5180 kg ha^{-1}) and harvest index (25.16%). The improvement in seed yield, straw yield and biological yield of safflower over no manure treatment (M_0) was 33.10%, 20.15% and 23.66%, respectively by the application of 5 t FYM ha^{-1} (M_2). Increased in seed yield, straw yield and biological yield due to application of 5 t FYM ha^{-1} this might be due to its beneficial effects both on soil and plant by making sufficient amounts available to plant nutrients throughout the growth period resulting in better uptake, plant vigour and superior seed yield (Shivakumar and Ahlawat, 2008) [17].

From Table 3 application of FYM @ 5 t ha^{-1} (M_1) was recorded significantly higher oil content (28.18%) and protein content (12.82%) over no manure treatment (M_0) and it was found statistically identical with treatment of greengram residue incorporation (M_2). Significantly lowest (25.33%) and protein content (12.18%) recorded under no manure treatment (M_0). Increased oil content might be due to mineralization of organic nutrients of FYM as well as microbial activity due to available organic carbon. The mineralization of organics enhanced oil content due to synthesis of fatty acids and their etherification by accelerating biochemical reaction in glycoxalate cycle. Similar results were also reported by Alam *et al.* (2009) [1]. Increased in protein content attributed to increase in nitrogen content an role of phosphorus in energy storage and transfer in forms of ADD and ATP which are essential for protein synthesis. Similar results recorded with Jain *et al.* (1995) [11].

Effect of nutrient management

The performance of safflower was significantly influenced by different nutrient management treatments. Data regarding to growth parameter showed in Table 1 revealed that, the highest growth attributes *viz*., plant height (80.42 cm) number of branches $plant^{-1}$ (17.43), leaf area $plant^{-1}$ (40.24 dm^2) and dry matter accumulation $plant^{-1}$ (70.37 g) were noticed in

treatment of SSNM (STCR equation) + $ZnSO_4$ @ 25 kg ha^{-1} + S @ 10 kg ha^{-1} (F_3) followed by treatments F_2, F_4, F_1 and F_0. Control plot recorded the lowest plant height (64.18 cm), number of branches $plant^{-1}$ (10.95), leaf area $plant^{-1}$ (31.56 dm^2) and dry matter accumulation $plant^{-1}$ (58.15 g). The improvement in plant height due to SSNM, sulphur, Zinc application might be due to proper nourishment of crop which helped in acceleration of various metabolic processes and optimum growth. The timely released of nutrients favourable for crop growth which favoured increased activity of meristematic cells and cell elongation and hence the higher plant height, no of branches per plant and leaf area per plant. The present finding was in conformity with Rahevar *et al* (2017). The higher total dry matter production might be due to the improvement in plant growth parameters as result of increased in nutrient concentration in plant part which are the constituent of proteins, chlorophyll etc. which in turn resulted in increased synthethesis of carbohydrates that are being utilized for buildup of new cells and their accumulation leading to higher dry matter production. Similar results were also reported by subramaniyan *et al.* (2001) [20], Anand (2010) [3], Veeramani *et al*.(2012) [23] and Bholanathsaha *et al.*(2015) [7].

Data showed in Table 2 indicated that, the treatment with soil applied fertilizer through SSNM (STCR equation) + $ZnSO_4$@ 25 kg ha^{-1} + S @ 10 kg ha^{-1} (F_3) obtained significantly highest seed yield (1818 kg ha^{-1}) straw yield (4948 kg ha^{-1}) and biological yield (6767 kg ha^{-1}) than rest of the nutrient management treatments and it was remain statistically at par with SSNM (STCR equation) (F_2). The lowest value in respect of seed yield (1214 kg ha^{-1}) straw yield (3555 kg ha^{-1}) and biological yield (4770 kg ha^{-1}) of safflower were noticed with treatment of no fertilizer (control). In case of harvest index (%) numerically highest (26.86%) value recorded with treatment receiving (F_3) SSNM (STCR equation) + ($ZnSO_4$ @ 25 kg ha^{-1} + S @ 10 kg ha^{-1}) followed by treatments F_2, F_4, F_1 and F_0. The increment in seed yield, straw yield and biological yield of safflower over (F_0) no fertilizer treatment was 49.75%, 39.18% and 41.86%, respectively by the application of SSNM (STCR equation) + $ZnSO_4$ @ 25 kg ha^{-1} + S @ 10 kg ha^{-1} (F_3). Increased in seed yield, straw yield and biological yield due to application of balanced fertilizer of SSNM (STCR equation) + $ZnSO_4$ @ 25 kg ha^{-1} + S @ 10 kg ha^{-1} might be due to enhancement in yield usually depends upon the total dry matter produced and its distribution among different parts of the plant. The higher seed yield may be attributed to higher total dry matter accumulation which in turn might be due to the availability of balanced and higher nutrition (available nitrogen, phosphorus, potassium as well sulphur and zinc) their uptake and translocation to the reproductive parts and their cumulative effect on improvement in yield attributing characters. Similar results were obtained by Mishra and Vyas (2015) [13], Subramanivan *et al*. (2001), Biradar *et al.* (2006) [8] Anand *et al* (2017) [2] and Rahevar *et al* (2017).

The perusal of data Table 3 revealed that, quality parameter such as oil content (29.49%) and protein content (13.11%) of safflower were significantly highest in treatment receiving SSNM (STCR equation) + $ZnSO_4$ @ 25 kg ha^{-1}+ S @ 10 kg ha^{-1} (F_3) followed by treatment SSNM (STCR equation) (F_2), SSNM NPK (deficient: +25% rec, medium: rec, high: - 25%) (F_4), Recommended NPK (F_1) and control (F_0). Similarly, lowest oil content (23.68%) and protein content (12.04%) were recorded in treatment of no manure (F_0). The improvement in oil content and protein content might be due to application of sulphur and $ZnSO_4$, there by enriched unsaturated fatty acid i.e. oleic and linoleic acid and this resulted into enhancing quality of oil in seed. Sulphur helps in convert of carbohydrate into soil. Similar finding were also reported by Jadhav *et al.* (2007) [10] and Jangilwad *et al.* (2019) [12].

Table 1: Growth attributes influenced by organic manures and nutrient management practices under *rainfed* condition.

Treatments	Plant height (cm)	No. of branches $plant^{-1}$	Leaf area $plant^{-1}$ (dm^2)	Dry matter accumulation plant (g)
Manure application				
M_0: No Manure	68.75	13.39	33.04	60.78
M_1: 5 t FYM ha^{-1}	75.78	15.58	37.60	67.24
M_2: Greengram residue incorporation	73.09	14.78	36.62	65.89
SE m±	1.21	0.46	0.62	0.99
CD @ 5%	3.46	1.32	1.77	2.83
Nutrient management				
F_0: Control (No fertilizer)	64.18	10.95	31.56	58.15
F_1: Recommended NPK	69.47	13.09	33.49	61.60
F_2: SSNM (STCR equation)	76.21	16.36	37.82	67.71
F_3: SSNM (STCR equation) + ($ZnSO_4$ @ 25 kg ha^{-1} + S @ 10 kg ha^{-1})	80.42	17.43	40.24	70.37
F_4: SSNM (NPK) (deficient + 25% rec.; Medium: rec.; high: -25% rec.)	72.43	15.09	35.64	65.35
SE m±	1.56	0.60	0.80	1.28
CD @ 5%	4.46	1.70	2.29	3.66
Interaction (M x F)				
SE m±	2.71	1.03	1.39	2.22
CD at 5%	NS	NS	NS	NS
GM	72.54	14.58	35.75	64.64

Table 2: Seed yield, straw yield, biological yield (kg ha^{-1}) and harvest index (%) of safflower as influenced by organic manures and nutrient management practices under *rainfed* condition

Treatments	Seed yield kg ha^{-1}	Straw yield kg ha^{-1}	Biological yield kg ha^{-1}	Harvest index (%)
Manure application				
M_0: No Manure	1311	3879	5180	25.16
M_1: 5 t FYM ha^{-1}	1745	4661	6406	27.21
M_2: Greengram residue incorporation	1629	4568	6198	26.29
SE m±	46	140	184	-
CD @ 5%	132	399	524	-
Nutrient management				
F_0: Control (No fertilizer)	1214	3555	4770	25.50
F_1: Recommended NPK	1504	4296	5801	25.78
F_2: SSNM (STCR equation)	1698	4677	6375	26.59
F_3: SSNM (STCR equation) + ($ZnSO_4$ @ 25 kg ha^{-1} + S @ 10 kg ha^{-1})	1818	4948	6767	26.86
F_4: SSNM (NPK) (deficient + 25% rec.; Medium: rec.; high: -25% rec.)	1573	4370	5943	26.38
SE m±	60	180	237	-
CD @ 5%	171	515	677	-
Interaction (M x F)				
SE m±	104	312	411	-
CD at 5%	NS	NS	NS	-
GM	1562	4370	5931	26.22

Table 3: Quality parameter of safflower as influenced by organic manures and nutrient management practices under *rainfed* condition

Treatments	Oil content (%)	Protein content (%)
Manure application		
M_0: No Manure	25.33	12.18
M_1: 5 t FYM ha^{-1}	28.16	12.82
M_2: Greengram residue incorporation	27.55	12.54
SE m±	0.32	0.11
CD @ 5%	0.92	0.32
Nutrient management		
F_0: Control (No fertilizer)	23.68	12.04
F_1: Recommended NPK	26.06	12.37
F_2: SSNM (STCR equation)	28.22	12.61
F_3: SSNM (STCR equation) + ($ZnSO_4$ @ 25 kg ha^{-1} + S @ 10 kg ha^{-1})	29.49	13.11
F_4: SSNM (NPK) (deficient + 25% rec.; Medium: rec.; high: -25% rec.)	27.63	12.42
SE m±	0.42	0.14
CD @ 5%	1.19	0.41
Interaction (M x F)		
SE m±	0.72	0.25
CD at 5%	NS	NS
GM	27.01	12.51

Conclusion

On the basis of one year data it can be concluded from the above finding that application of 5 t FYM ha^{-1} registered significantly superior over rest of treatments with respect to growth attributes, yield and quality parameters. Similarly, among nutrient management treatments application of fertilizer through SSNM (STCR equation) + $ZnSO_4$ @ 25 kg ha^{-1} + S @10 kg ha^{-1} recorded higher growth, yield and quality component of safflower under *rainfed* condition.

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